MATERIALS PROCESSING

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IMPROVING PROCESSING OF LARGE PRISMS

S. K. Mamonov

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The process schemes for processing large prisms from blocking in gypsum and treatment with free abrasives with conversion to individual strengthening and use of a combined diamond instrument in coarse and fine polishing operations were examined. The results of improving processing with conversion to fine polishing operations from a spot to a lamellar instrument and from glass wool to PTS cloth in polishing are reported.

Prisms for telescopic systems are a separate class of optical parts. Prisms have the shape of a parallepiped with one and two reflecting bevels and other shapes. The element with one bevel (Fig. 1) whose height, width, and thickness reached 180, 240, and 46 mm with tolerances of 1 – 3 mm for the geometric dimensions, ± 20 – 30° for the angles, and 1 – 0.5 mm beveled width, is the most common.

The prisms are made from K108 optical glass (GOST 3514–94) and substitute brands K100 and K110 (OST 3-22–77). The allowance for processing is 3 – 8 mm a side and the weight reaches 3.6 kg. The roughness requirements R of refracting and reflecting surfaces are 0.10 and 0.05 for a class seven smoothness value. The remaining surfaces are polished with $R_z = 2.5$. In view of the mixed character of the individual surfaces, they are completely polished and then the corresponding part is ground.

The quality of a prism, relating both to processing of refracting and reflecting surfaces and the quality of the material, is evaluated by the distortion of an arbitrary lined object. Distortion of the image in the light zone at a maximum distance of 1 mm from the edge of the item is acceptable. A silver or aluminum coating is chemically applied on the reflecting surfaces by the vacuum method. A special instrument (USSR Inventor's Certificate No. 857297) can be used to delimit the silvering zone, which excludes removal of excess silver by acid etching. The reflecting and dull surfaces are coated with Bakelite varnish with fillers.

The manufacturing process for fabrication of this type of part consisted of plastering the prisms in a block 1 m in diameter, polishing with a free abrasive with the corresponding passes, and polishing all sides successively with a glass wool – cloth instrument on ShP-1000, ShP2-1000, SP-1000 machines with repeated plastering.

The negative aspects of this method are: impossibility of circular feed of the grinding and polishing suspensions, difficulty in controlling the quality of the treated surfaces, significant number of auxiliary operations (varnishing, plastering and deplastering, cleaning, washing [1]), and contamination of the premises with plaster and plaster wastes.

A version of simultaneously grinding four faces of the prism in a stack with a cushion between them (USSR Inventor's Certificate No. 246344) was proposed for implementing the diamond treatment. The bench that holds the prism enters the processing zone when the stack is laid and fixed and is removed during processing. Testing this version did not lead to its practical implementation.

The next improvement passed through a series of stages (equipment, instrument, means of attaching the parts) and was definitively formulated with the introduction of models 3B756, 3D756, VS3-52 metal-processing face grinders in optical production with tables 0.8 and 1.0 m in diameter, in-

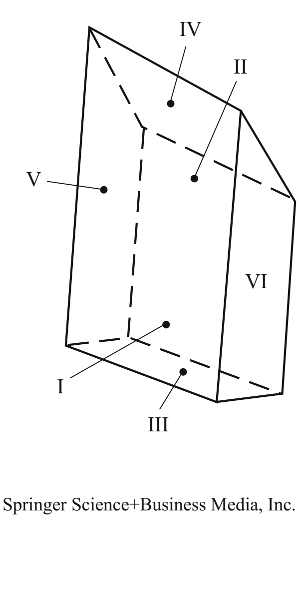

Fig. 1. Prism with one reflecting bevel: I and VI) treated sides.

TABLE 1

Treated side of prism	Polishing tool	Characteristics of elements (brand, granularity and concentration of diamond powder, binder)	Operating conditions		Specific consumption of diamond powder, car/dm^3 *	
			table rotation rate, min^{-1}	tool feed, mm/min	average	range
I	Single-row on plate elements	AS15, 315/250, 100%, M1-1	15.00	0.25	0.997	0.15 – 2.15
		AS15, 250/200, 25%, M1-1			0.620	0.24 – 1.89
		RX1, 250/200, 25%, M1-1			0.610	0.10 – 1.05
III	Double-row on plate elements	External row	0.14	3 – 4**	1.430	0.35 – 3.94
IV		AS15/20, 315/250, 100%, M1-1	0.20			
V		Internal row	0.14			
VI		AS15/20, 160/125, 50%, M1-1	0.14	0.2 – 0.3**		
II	On spot elements	AS15, 100/80, 50%, M3-12	15.00	0.1	–	–

* According to the data in [3].

** Removed per table rotation, mm.

cluding a version of updating them for operation in the milling mode [2] and creating a pneumatic mounting system. The latter was made by setting a special coupling in the center of the table for compressed air feed. It goes through a hose to cocks for controlling the fastening devices positioned along the periphery of the bench table. The apparatus consists of a two-way collecting air cylinder with divergent pistons, adjustable housing with the base surfaces for semiproducts, and a control cock that provides for passage of compressed air into one chamber or the other of the air cylinder by turning a lever. The pistons of the air cylinders are made of a nonferrous metal to eliminate the effect of the magnetic field of the bench table on them.

Fig. 2. Coarse polishing of the plans of a prism.

Prism sides I and II are polished laid out over the entire table and attached in an apparatus holding two units (Fig. 2) and feeding the tool from above according to the operating scheme of the benches used. In order to satisfy the requirement for obstruction of the obtuse angle, surface II is polished after treating the other sides by the cutting method (milling). In this case, two semiproducts are placed in the pneumatic device in treating sides III and IV (Fig. 3*a*) and four semiproducts are installed in polishing sides V and VI. In all passages, the diamond layer is broken up with emery stone selected as a function of the diamond powder fraction in the tool used and secured with one of the semiproducts. The data on processing the sides of a single-bevel prism with a tool 510 mm in diameter with a rotation rate of 980 min^{-1} are reported in Table 1. The design of the tool for coarse polishing based on plate elements and the analysis of its working capacity in a wide range of diamond powders, binder compositions, and lubricating-cooling fluids are examined in [3]. As the data in Table 1 show, of the three single-row tools used, the tools with a smaller diamond grain size and lower concentration are most effective. The values of the specific consumption are almost the same for the initial AS15 diamond powder and the secondary RX1 powder obtained by etching from used element residues.

The double-row tool (USSR Inventor's Certificate No. 1349986) [3] was basically used in processing this type of parts and the data in Table 1 were obtained as a result of recording the operation of 292 grinders with elements on ASA15 and AS20 diamond powders in versions of identity and difference with respect to the external and internal rows. A small number of tools that differed in the brands of diamond powders for the same size and concentration was identified (Table 2). The high specific consumption in milling in comparison to flat grinding from above is probably due to the impact character of operation of the $12 \times 20 \times 2.2$ mm

TABLE 2

Diamond powder (external and internal rows)	Number of tools considered	Specific consumption of diamond powder, car/dm^3	
		average	range
AS15/AS20 – AS65	16	1.13	0.58 – 1.84
AS32 – AS15/AS20	10	1.36	0.36 – 3.37
AS32 – AS65	6	1.90	1.25 – 3.25
AS20/ASK – ASK/AS20	9	1.53	0.51 – 3.33
AS65 – AS65	3	1.55	0.76 – 2.38

elements with hardness of 76 – 46 units HR_B of the external and 65 – 40 units HR_B for the internal rows.

Fine diamond grinding and polishing are conducted on ShPS-350M benches at a spindle rotation rate of 527 min^{-1} and 29 double deformation rocking movements successively in one device. Two parts — sides I and IV (Fig. 3*b*), and four parts — side III — are simultaneously processed. A special pneumatic unit is used to block and free the parts in the devices.

There were two stages of improvement of the manufacturing process.

In the first stage, fine diamond grinding of sides I and IV was conducted with a grinder with spot elements (TU 3-269–84) in two passes (brand and granularity of the diamond powder: 1) AS15, 100/80; 2) ASM, 28/20 with a 12.5% concentration in MZ-15-1 binder. Side III was treated in one pass with the tool at position 2. Polishing was conducted with fine-wool industrial felt (GOST 288–72) impregnated with a composition based on a solution of Bakelite varnish with BF2 adhesive. Treatment began from the surface of bevel IV, so that the nonplaneness of the reflecting face was within the limits of 0.025 μm.

Grinders on plate elements measuring 20 × 15 × 1.5 mm (TU 3-1660–88; USSR Inventor's Certificate No. 1311921) [4] for side I in two passes: 1) AS 15, 100/80 or 80/63; 2) ASM, 28/20 or 20/14 with a 12.5% concentration in M3-15-2 binder; sides III and IV were ground in a second pass. Specially impregnated (USSR Inventor's Certificate No. 1508490) PTS fulling fabric (TU17RSFSR 42-Yu735–84, USSR Inventor's Certificate No. 1202838) was used for polishing [5]. This allowed reducing the block treatment time by 1.7 times (Table 3) and increasing the grinding efficiency by

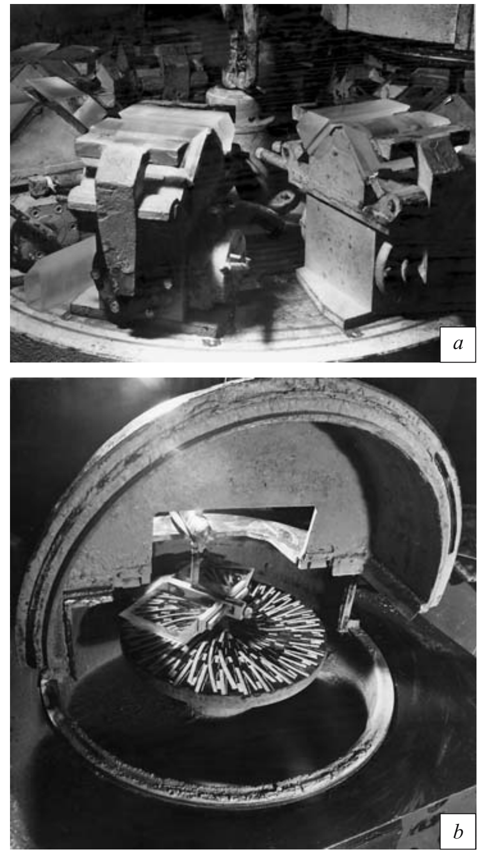

Fig. 3. Treatment of prism bevel by milling (*a*) and fine diamond polishing of prism planes (*b*).

TABLE 3

Operation	Processed side of prism	In plaster block			In pneumatic devices				
		number of parts	duration of treatment, min		number of parts	duration of treatment, min			
			block	related to one surface		block		related to one surface	
						stage I	stage II	stage I	stage II
Grinding	I	50		1.20	2	2.80	1.40	2.00	1.00
	III	105	60*	0.57	4	2.00	0.50	1.00	0.25
	IV	80		0.75	2	2.80	1.40	1.00	0.50
Polishing	I	50		3.00	2	9.00	4.50	6.00	3.00
	III	105	150	1.43	4	9.00	2.25	5.00	1.25
	IV	80		1.87	2	9.00	4.50	6.00	2.50

* Grinding in three 20-min passes with M28 grinding powders and M20 cast-iron grinder and M20 vinyl plastic grinder.

1.9 times. As a result, the times spent for treating one surface in the conditions of one treatment were comparable to manufacture in a plaster block with a significant reduction in auxiliary materials.

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